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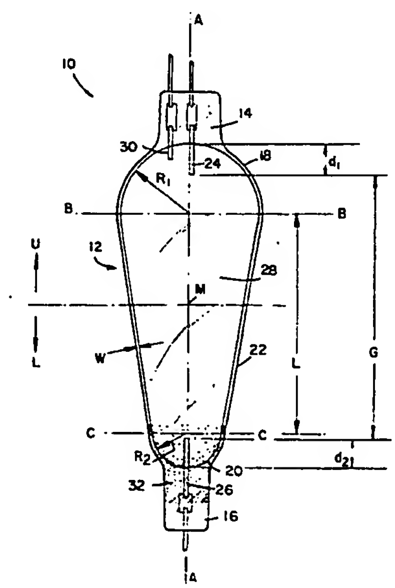
(54) Arc tube having two apposed hemispherical regions and an intermediate conical region; and high-intensity arc discharge lamp employing same.

(57) This invention provides a specially shaped arc tube for a high-intensity arc discharge lamp, particularly a lamp for vertical operation. The arc tube has a hemispherical top with radius R_1, a hemispherical bottom with radius R_2, and a middle section being a frustum of a right circular cone which on one end mates with the top and on the other end mates with the bottom so that the arc tube has a smooth and continuous surface. R_2 is greater than or equal to two millimeters. The ratio R_1/R_2 is always greater than one, and in preferred embodiments R_1/R_2 is within the range of 1.5 to 3, inclusive. This arc tube virtually eliminates species segregation in metal halide lamps even though the arc is vertical. The invention also includes an arc discharge lamp employing an arc tube as described herein together with an optimum choice of design parameters, such as wall loading and nitrogen pressure within the outer envelope. The virtual elimination of species segregation of the additives along the arc axis provides this lamp with higher luminous output, lower color temperature, improved luminous efficacy, extended life, and no perceptible flicker with electrical current at fifty hertz compared with counterparts in the existing art.



ACTORUM AG

ARC TUBE HAVING TWO OPPOSED HEMISPHERICAL REGIONS AND AN INTERMEDIATE CONICAL REGION; AND HIGH-INTENSITY ARC DISCHARGE LAMP EMPLOYING SAME

CROSS REFERENCES TO RELATED APPLICATIONS

Attorney's Docket No. 83-1-105, filed concurrently herewith and assigned to the assignee of this application, contains related subject matter.

TECHNICAL FIELD

The present invention relates to the field of high-intensity arc discharge lamps and more particularly to such lamps employing an arc tube having two opposed hemispherical regions with an intermediate conical region.

BACKGROUND ART

High-intensity arc discharge lamps are those in which the light-producing arc is stabilized by wall temperature, and the arc tube has a wall loading in excess of three watts per square centimeter. These lamps include groups of lamps known as mercury, metal halide, and high-pressure sodium.

Within the arc tube of a high-intensity discharge lamp, operating temperatures generally range between 500° and 1000° C and operating pressures may range between one and ten atmospheres. The fill gas within the arc tube may comprise, for example, mercury, an inert gas, and one more metal-halide additives. Thus, the chemical reactions extant within an operating arc tube are quite complex. Moreover, the arc discharge may be affected by convection currents within the arc tube.

The chemistry within the arc tube is affected by the shape of the arc tube. Within the existing art, various arc-tube shapes are employed; certain benefits and detriments are associated with each shape.

Many commercial metal halide arc discharge lamps for general illumination have a substantially tubular arc tube with a uniform diameter. These lamps have the advantage that they may be operated either horizontally or vertically. Some lamps, designed for horizontal operation only, have an arched arc tube. The arched arc tube conforms with the steady state shape of the arc discharge (which is bowed upward because of convection currents) thereby improving lamp performance. For an example of this type of arc tube, see U.S. Patent No. 3,858,078, by Koury.

In U.S. Patent 3,883,766, Fohl teaches that an arc tube having a non-uniform diameter, i.e., having an expanded section at or near the center of the arc tube, increases efficacy in vertically operated lamps. The expanded central section reduces the shear between the upward and downward convective flow within the arc tube during operation of the lamp.

See also U.S. Patent No. 3,896,326, by Fohl, where an arc tube with an expanded section has an additional benefit of reducing species segregation in metal-halide lamps for vertical operation.

Some types of compact source arc discharge lamps have arc tubes with non-uniform diameters, such as short arc lamps and heavily loaded capillary lamps. Short arc lamps generally contain a spherical arc tube and have an arc discharge that is electrode stabilized; in these lamps, the arc length is small compared to the arc-tube diameter, the shape of the arc discharge is independent of the shape of the arc tube, and the arc discharge is not affected by convection currents within the arc tube.

Capillary arc discharge lamps have been made with a slight bulge at the hottest portion of the arc tube in order to prevent melting of the glass wall. In these lamps, the arc discharge extends to the walls of the arc tube and is confined thereby. The arc discharge is not significantly affected by convection currents within the arc

tube. Capillary lamps are generally so heavily loaded (lamp wattage per square centimeter of internal surface area of the arc tube) that they must be artificially cooled in order to prevent the arc tube from melting.

In U.S. Patent No. 2,190,657, by Germer, there is disclosed an arc tube for vertical operation wherein there is a bulge in the upper end of the tube. Germer teaches that the bulge is required to prevent melting of the upper end of the tube which is heated more than the remainder of the tube by uprising heat. Germer also teaches that exceedingly thick walls of quartz material are required for the arc tube in order to resist the high temperatures and pressures.

In Canadian Patent No. 508,525, issued December 28, 1954, by Francis et al., there is disclosed an oval-shaped arc tube having a wider diameter at the upper end than at the lower end in order that the operating wall temperature will not vary greatly over the surface of the arc tube.

Despite the contributions to the art made by the above-mentioned patentees, significant challenges still remain in the field. A persistent problem is that of species segregation in vertically operated metal halide lamps. When the arc tube is operated vertically (or other than horizontally), the amount of metal halide additive in vapor phase may vary substantially along the arc discharge. Nonuniform species concentration results in non-uniform spectral emission along the arc discharge which adversely affects the color temperature and efficacy of these lamps.

Lamps designers have sought to minimize species segregation in vertically operated lamps with only modest degrees of success. Furthermore, there is an ongoing quest to improve lamp operating characteristics, such as luminous efficacy, color temperature, lamp life, and flicker. It would be an advancement in the art if an optimum design could be provided for vertically operated high-intensity arc discharge lamps which substantially eliminates species segregation and provides improved operating characteristics.

DISCLOSURE OF THE INVENTION

It is, therefore, an object of the invention to obviate the deficiencies in the prior art.

It is another object of the invention to provide an arc tube for a high-intensity arc discharge lamp which substantially eliminates species segregation along the axis of the arc discharge during operation of the lamp in a vertical (or other than horizontal) position.

It is a further object of the invention to provide an arc tube for a high-intensity arc discharge lamp which provides improved luminous efficacy with no increase in wall loading.

It is still another object of this invention to provide an arc tube for a high-intensity discharge lamp which provides light with a lower color temperature than that of counterparts in the existing art with minimal sacrifice in the general color rendering index.

Another object of the invention is to provide a high-intensity discharge lamp with extended life compared to counterparts in the existing art.

A further object of the invention is to provide an arc tube for a high-intensity discharge lamp which produces light that has virtually no flicker perceptible to the human eye when the lamp is operated with alternating electrical current of fifty hertz.

These objects are accomplished, in one aspect of the invention, by the provision of an arc tube for a high-intensity arc discharge lamp, as well as a high-intensity arc discharge lamp for vertical operation employing same, such arc tube comprising an elongated body with first and second opposed ends. The body of the arc tube hermetically encloses an interior. The body comprises a first region adjoining the first end, a second region adjoining the second end, and a third region intermediate the first and second regions.

The first region is substantially hemispherical in shape with radius R_1. The second region is substantially hemispherical in shape with radius R_2. The third region is substantially a frustum of a right circular cone. R_2 is greater than or equal to two millimeters, and the ratio R_1/R_2 is greater than one.

The arc tube has two electrodes, one being mounted in the first end and protruding into the interior of the arc tube, the other electrode being mounted in the second end and protruding into the interior of the arc tube. A fill including mercury and at least one metal halide additive is contained within the interior of the arc tube. The fill is capable of generating and sustaining an electrical arc therethrough. Means are provided for supplying electrical energy to the electrodes.

Vertically operating high-intensity lamps having arc tubes as herein described will have substantially improved operating characteristics compared with their counterparts in the existing art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an enlarged elevational view of an embodiment of the invention;

FIG. 2 is an elevational view of another embodiment of the invention;

FIG. 3 is a graph of luminous efficacy in lumens per watt with respect to wall loading in watts per square centimeter for the embodiment of the invention shown in FIG. 2;

FIG. 4 is a graph of luminous efficacy in lumens per watt with respect to gas pressure within the outer envelope measured in Torr for the embodiment of the invention shown in FIG. 2;

FIG. 5 is an elevational view of the arc tube of FIG. 1 showing observed temperatures on the wall of the arc tube during vertical operation thereof;

FIG. 6 contains plots of the arc plasma temperature in Kelvin as a function of distance in millimeters from the top electrode for the embodiment of the invention contained in FIG. 2 and for a lamp representative of the existing art; and

FIG. 7 is an elevational view of the embodiment of the invention shown in FIG. 1 wherein the contours of the convention currents within an operating arc tube are illustrated.

BEST MODE FOR CARRYING OUT THE INVENTION

For a better understanding of the present invention, together with other and further objects, advantages, and capabilities thereof, reference is made to the following disclosure and appended claims taken in conjunction with the above-described drawings.

FIG. 1 shows arc tube 10 having an elongated body 12 and central axis A-A. Body 12 comprises region 18 adjoining end 14, region 20 adjoining end 16, and region 22 being intermediate regions 18 and 20. Region 18 is substantially hemispherical in shape with radius R_1. Line B-B shows the approximate boundary between regions 18 and 22. Region 20 is substantially hemispherical in shape with radius R_2. Line C-C shows the approximate boundary between regions 20 and 22. Region 22 is substantially a frustum of a right circular cone wherein the radii of the two parallel planes of the frustum are approximately R_1 and R_2 so that region 22 will join regions 18 and 20, respectively, to form a smooth and continuous surface.

In the embodiment shown in FIG. 1, arc tube 10 is designed to be operated vertically with end 16 being the lower end, i.e., end 16 is closer to the earth when arc tube 10 is operationally positioned, and end 14 being the upper end.

Arc tube 10 encloses a hermetically sealed interior 28. Interior 28 contains a fill (not shown in the drawing) which is capable of generating and sustaining an electrical arc therethrough. Electrodes 24 and 26 are mounted into ends 14 and 16, respectively, of arc tube 10; these electrodes protrude into interior 28. Starting electrode 30, which is optional, is mounted in end 14.

Ends 14 and 16 are formed by a novel method of press sealing. For a detailed description of this method, see the copending application by Rothwell et al., having attorney's docket No. 83-1-105, filed concurrently herewith and assigned to the assignee hereof, the entire contents of which are incorporated herein by reference.

As illustrated in the drawing, electrical current is provided from the lead-in wires to electrodes 24 and 26 by means of conventional foil strips, e.g., molybdenum, imbedded in the press seals.

In the embodiment of FIG. 1, R_1=8 mm, R_2=5 mm, and the ratio R_1/R_2=1.6. The distance, L, between the centers of regions 18 and 20 is 20.5 mm. The insertion depth d_1 of electrode 24 is 4 mm; and the insertion depth d_2 of electrode 26 is 4 mm. With these parameters defined, distance G between the interior extremities of electrodes 24 and 26 is 25.5 mm. Body 12 has wall thickness W of 1.5 mm. The values of the parameters provided herein are approximate and not critical to the invention.

Within interior 28 in the embodiment of FIG. 1, the fill is a mixture of mercury, an inert gas (to aid lamp starting), and metal halide additives, e.g., sodium iodide (NaI) and scandium iodide (ScI_3). A conventional heat-reflecting coating 32, e.g., Zirconium Oxide (ZrO_2), covers portions of bottom region 20 and end 16 in order to reflect infrared radiation back into the lower portion of arc tube 10.

FIG. 2 shows a high-intensity arc discharge lamp 40 intended for vertical operation with lamp base 42 up. Arc tube 10 is operationally mounted within light-transmissive outer envelope 44 with end 16 down. In the embodiment of FIG. 2, environment 46 surrounds arc tube 10 and is hermetically sealed within outer envelope 44.

Several examples of lamp 40 were constructed and tested. FIG. 3 shows a plot of luminous output of lamp 40 in lumens per watt as a function of wall loading of arc tube 10 in watts per square centimeter. As may be seen from the plot, the wall loading varied from approximately 12 to 16.7 watts per square centimeter. This range corresponds to wattage applied to lamp 40 ranging from 150 to 212 watts. The data in FIG. 3 pertains to environment 46 being a vacuum. The plot shows that the luminous output increases only slightly with increasing wattage indicating that the arc tube geometry is nearly optimum.

Further tests were conducted with lamp 40 wherein environment 46 was changed from a vacuum to being a gaseous fill, e.g., nitrogen, at varying pressures. FIG. 4 is a plot of luminous output in lumens per watt for lamp 40 operating with 175 watts power with respect to nitrogen pressure within outer envelope 44 measured in Torr. The plot shows that an optimum heat transfer is obtained with 200 Torr of nitrogen. The dashed coordinate lines in FIG. 4 indicate the optimum point on the curve corresponding to approximately 113 lumens per watt with 200 Torr of nitrogen. When environment 46 is not a vacuum, additional cooling of the outer arc tube walls occurs due to convection currents within the outer envelope.

The curve in FIG. 4 comprises two parts, P1 and P2, as shown in the drawing. P1 corresponds to outer pressures of nitrogen less than 200 Torr; P2 corresponds to outer pressures of nitrogen exceeding 200 Torr. The position of the arc discharge was unstable during operation of lamp 40 in the lower P1-region. The arc tended to bow to one side thereby reducing the effective plasma volume producing light. By adjusting the outer pressure of nitrogen up to approximately 200 Torr, the arc stably assumed a central position within the arc tube whereby maximum utilization of the arc tube volume was realized. In the P2 region, further increasing the outer pressure of nitrogen has little effect, if any, on luminous output.

Once the arc discharge has been centrally stabilized by convective cooling of the outerwalls of the arc tube, no additional benefits are apparent from further increasing the outer pressure.

The 175 watt power rating used in obtaining the data of FIG. 4 corresponds to a wall loading of approximately 13.8 watts per square centimeter for the arc tube of lamp 40. Referring to FIG. 3, the dashed coordinate lines indicate a luminous output of approximately 96 lumens per watt for lamp 40 operated at 175 watts with a vacuum within the outer envelope. Thus, an increase in luminous output from 96 to 113 lumens per watt (18%), approximately, has been realized by an optimal choice of pressure within the outer envelope.

The wall of arc tube 10 is very nearly isothermal during operation in the embodiment of FIG. 2. FIG. 5 shows the temperature distribution over the arc tube wall during vertical operation of arc tube 10 with end 16 down. The temperatures are shown at six locations, labelled L1, L2,..., L6, in the drawing. Note that the temperature variation is only approximately 25° over the body of arc tube 10. This result is attributable to the special geometry of arc tube 10.

It is believed that lower color temperature is the result of reduced species segregation. A major function of the metal halide additives is to improve the output spectrum of the lamp over that of mercury lamps. The metal halide additives, particularly metal iodides, emit considerable energy in the red and other visible parts of the spectrum which results in vastly improved color rendition. On the other hand, to the extent the metal halides are not present within the arc plasma, or a portion thereof, the benefits of the additives are lost. Accordingly, the degree of species segregation can be estimated by measurements of corollated color temperature.

The Sylvania M175 high-intensity arc discharge lamp was selected as a representative of the existing art. This lamp is intended for vertical operation; it was a straight tubular arc tube; the power-rating is 175 watts. The M175 has a corollated color

temperature of 4500° K and a color rendering index of 65. Lamp 40, which is essentially the same lamp as the M175 except for the specially shaped arc tube as has been described herein, has a corollated color temperature of 3400° K and a color rending index of 60. Thus, lamp 40 exhibits a substantial improvement in color rendering ability (more than 1000° K decrease in corollated color temperature). The two lamps have a slight difference in their color rendering indices; however a comparison of the two indices is not meaningful because the chromaticity or color temperatures of the two lamps differ by so great a degree.

Additional observations were made on the same two lamps which further support the conclusion that lamp 40 has negligible species segregation even though the arc discharge is vertical. The plasma temperatures of the arcs of both lamps were spectroscopically observed at different points along the arc. FIG. 6 contains least-squares fitted graphs of these temperatures in Kelvin as a function of the distance in millimeters from the top electrode.

In the case of the Sylvania M175 lamp, labelled as "Existing Art" in the diagram, the arc plasma temperature is considerably higher near the top electrode. The arc temperature increases approximately 7.5° K per millimeter from the bottom electrode toward the top electrode. Since the mercury in the fill burns hotter than do the metal halide additives, this indicates an absence or undersupply of metal halide additives in the upper arc portion. On the other hand, lamp 40 has more uniform plasma temperatures throughout the entire arc with the upper arc being slightly cooler than the lower arc. The arc temperature decreases approximately 2.2° K per millimeter from the bottom electrode toward the top electrode. The temperature variation over the entire arc length has been reduced, by approximately 70%, with lamp 40. The fact that lamp 40 operates with an arc discharge having a substantially uniform plasma temperature over the entire arc discharge

corroborates the conclusion that the metal halide additives are in plentiful supply at all points in the arc and that the problem of species segregation has been overcome by the special arc tube geometry employed by lamp 40.

As has been explained in the foregoing, the special geometry of arc tube 10 provides the improved operating characteristics of lamp 40. Referring to FIG. 1, point M is the midpoint between the internal extremities of electrodes 24 and 26. Since arc tube 10 is designed for substantially vertical operation, arrow U points upward (away from the earth) and arrow D points downward (toward the earth) when arc tube 10 is operationally positioned.

FIG. 1 shows that arc tube 10 has greater surface area and interior volume in the upper portion of the arc tube. This design feature provides greater surface cooling of the upper portion of the arc tube. Within arc tube 10, heat will rise into the upper portion because of gravity and interior convection currents. The greater cooling ability of the upper surface area is necessary to obtain a substantially isothermal temperature distribution over the walls of arc tube 10.

FIG. 7 illustrates contours of convection currents within an operating arc tube 10 positioned with end 16 down. These contours are shown as dashed lines in the drawing. The arc discharge is positioned on central axis A-A. The direction of the convection current is upward surrounding the arc discharge and downward adjacent to the walls of arc tube 10. Maintenance of continuous convective flow within arc tube 10 is essential for replenishing the arc discharge with the metal halide additives so that species segregation does not occur. Hemispherical top region 18 and hemispherical bottom region 20 are critical regions because each region changes the direction of convective flow. Such redirection should occur with a minimum of turbulence and without causing a vortex within arc tube 10. The hemispherical shapes of regions 18 and 20 have experimentally been determined to be optimum.

Region 20 encloses the lowest portion of interior 28 which is potentially the coolest portion of the interior. A heat-reflecting coating, such as zirconium oxide, is frequently employed on the exterior of region 20 to assist in maintaining the metal halides in vapor state. A continuous convective flow along the walls of region 20 is important for the purposes of supplying heat to the region (via hot gases from the upper region) and by sweeping the metal halide additives out of region 20 upward to arc discharge. Experimentation has shown that R_2 should be greater than or equal to two millimeters so that the metal halides additives will not collect in condensate form in the apex portion of region 20.

Conical region 22 provides an optimum intermediate region between hemispherical top 18 and hemispherical bottom 20. The increasing radius of a conical cross-section as the cross-section is advanced toward top 18 provides greater surface area and interior volume in the upper portion of arc tube 10 which is essential to the isothermal property of the arc tube. Region 22 also provides essentially straight convective contours between the opposed hemispherical ends of differing radii.

The ratio R_1/R_2 is an important design parameter in the overall heat balance equation for the arc tube. Since the relative surface areas of the upper and lower portions of the arc tube are directly related to the respective radii, the cooling ability of each portion is likewise related. An optimum choice of R_1/R_2 is dependent on many factors, such as the length of the arc discharge and the electrode insertion depths; the chemical properties of the fill and metal halide additives as well as the internal operating pressure; the electrical voltage across the electrodes; etc. An optimum range for this ratio for high intensity arc discharge lamps generally of 1000 watts or less has been computed theoretically and experimentally verified to be approximately between 1.5 and 3, preferably within 1.5 and 2.5.

Initial data from life test of twenty examples of lamp 40 indicate that luminous efficacy and lamp life will be improved due to the optimum shaping of the arc tube. At 100 hours, the average luminous efficacy for the example lamps is approximately 90 lumens per watt. This value is more than ten percent higher than that of the standard vertically burning lamp with a tubular arc tube and equivalent loading. The substantially improved efficacy together with the lower wall loading suggests that the average life of lamp 40 will be appreciably extended.

Lamp 40 provides light which has virtually no flicker when the lamp is operated with alternating electrical current of approximately fifty hertz. For purposes herein, flicker is defined as half-frequency light-intensity differences which are perceptible to the human eye.

Photometric measurements of the light output made on lamps in the existing art in lamp 40 indicate that the perception of flicker results from mercury radiation modulation which is not concealed by radiation produced by metal-halide additives. The greater the degree of axial mixing of the metal halide additives along the arc discharge, the less pronounced is the eye's perception of flicker. Flicker is not a problem in arc discharge lamps operated horizontally, because there is no axial segregation when the arc is horizontal. Nor is flicker a problem when the alternating current is sixty hertz (or higher) because the frequency just exceeds the eye's detection ability.

Flicker is a serious problem in vertically operated metal halide lamps of the existing art operated at approximately fifty hertz. Because of the deficiency of additives in the upper arc, mercury radiation is prevalent and flicker occurs. Since lamp 40 has the feature that axial mixing of the additives is uniform along the vertical arc, flicker is virtually eliminated at fifty hertz. Radiation emitted from metals in the additives, e.g., sodium and scandium, when mixed with the mercury radiation, is sufficiently intense to overcome the eye's sensation of flicker.

While there have been shown what are at present considered to be preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications can be made herein without departing from the scope of the invention as defined by the appended claims.

CLAIMS:

1. An arc tube for an high-intensity arc discharge lamp, said arc tube comprising:

(a) an elongated body with first and second opposed ends, said body hermetically enclosing an interior, said body comprising a first region adjoining said first end, a second region adjoining said second end, and a third region intermediate said first and second regions, said first region being substantially hemispherical in shape with radius R_1, said second region being substantially hemispherical in shape with radius R_2, said third region being substantially a frustum of a right circular cone, wherein R_2 is greater than or equal to two millimeters and the ratio R_1/R_2 is greater than one;

(b) two electrodes, one electrode being mounted in said first end and protruding into said interior, the other electrode being mounted in said second end and protruding into said interior;

(c) a fill contained within said interior, said fill including mercury and at least one metal halide additive, said fill being capable of generating and sustaining an electrical arc therethrough; and

(d) means for providing electrical energy to said electrodes.

2. An arc tube as described in Claim 1 wherein the ratio R_1/R_2 is approximately within the range of 1.5 to 3.

3. An arc tube as described in Claim 2 wherein the distance between the centers of said first hemispherical region and said second hemispherical region is approximately eighty millimeters or less.

4. A high-intensity arc discharge lamp for vertical operation comprising:

(a) a light-transmissive outer envelope;

(b) an arc tube operationally mounted within said outer envelope, said arc tube having an elongated body with upper and lower opposed ends wherein said lower end is closer to the earth than said upper end when said lamp is operationally positioned, said body hermetically enclosing an interior, said body comprising an upper region adjoining said upper end, a lower region adjoining said lower end, and a third region intermediate said upper and lower regions, said upper region being substantially hemispherical in shape with radius R_1, said lower region being substantially hemispherical in shape with radius R_2, said third region being substantially a frustum of a right circular cone, wherein R_2 is greater than or equal to two millimeters and the ratio R_1/R_2 is greater than one;

(c) two electrodes, one electrode being mounted in said first end and protruding into said interior, the other electrode being mounted in said second end and protruding into said interior;

(d) a fill contained within said interior, said fill including mercury and at least one metal halide additive, said fill being capable of generating and sustaining an electrical arc therethrough, and

(e) means for structurally and electrically completing said lamp.

5. A lamp as described in Claim 4 wherein the ratio R_1/R_2 is approximately within the range of 1.5 to 3.

6. A lamp as described in Claim 5 wherein the distance between the centers of said upper hemispherical region and said lower hemispherical region is approximately 80 millimeters or less.

7. A lamp as described in Claim 6 wherein a gaseous fill is hermetically enclosed within said outer envelope.

8. A lamp as described in Claim 7 wherein said fill within said interior of said arc tube includes sodium iodide (NaI) and scandium iodide (SCI_3).

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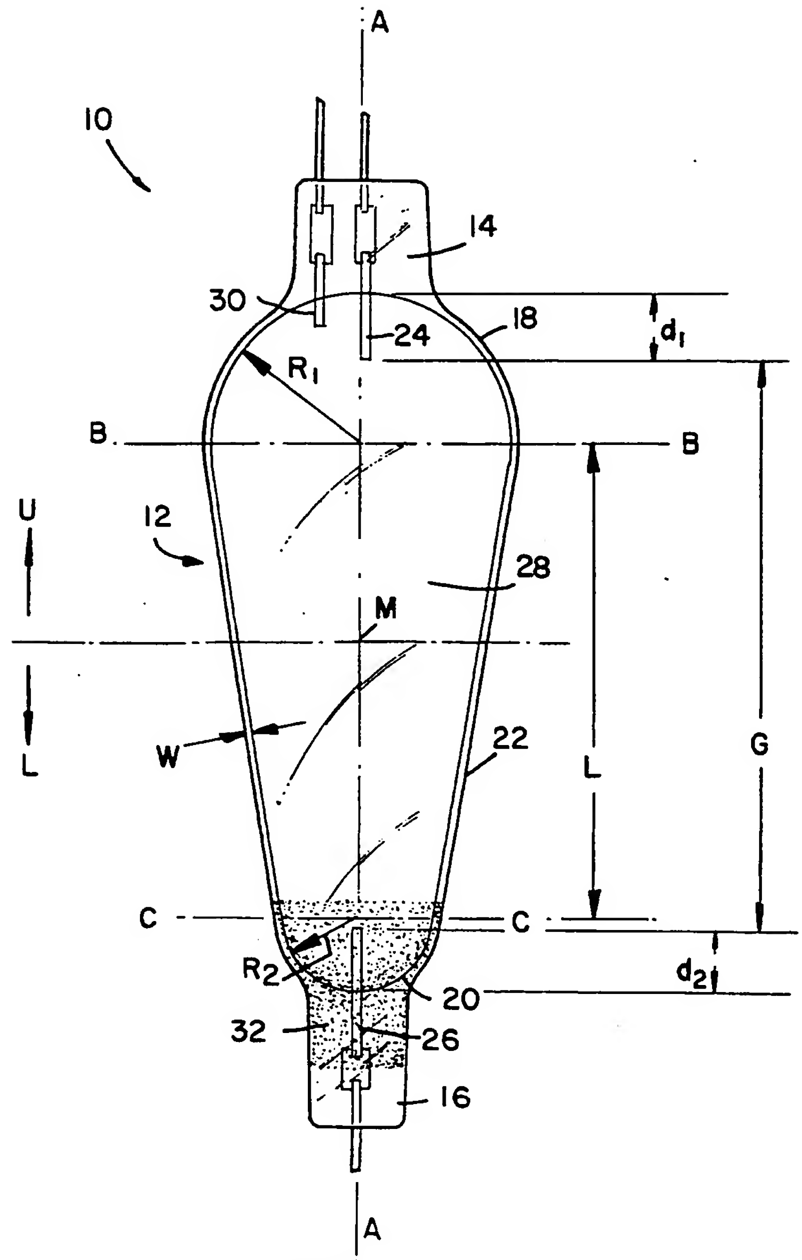


FIG. 1

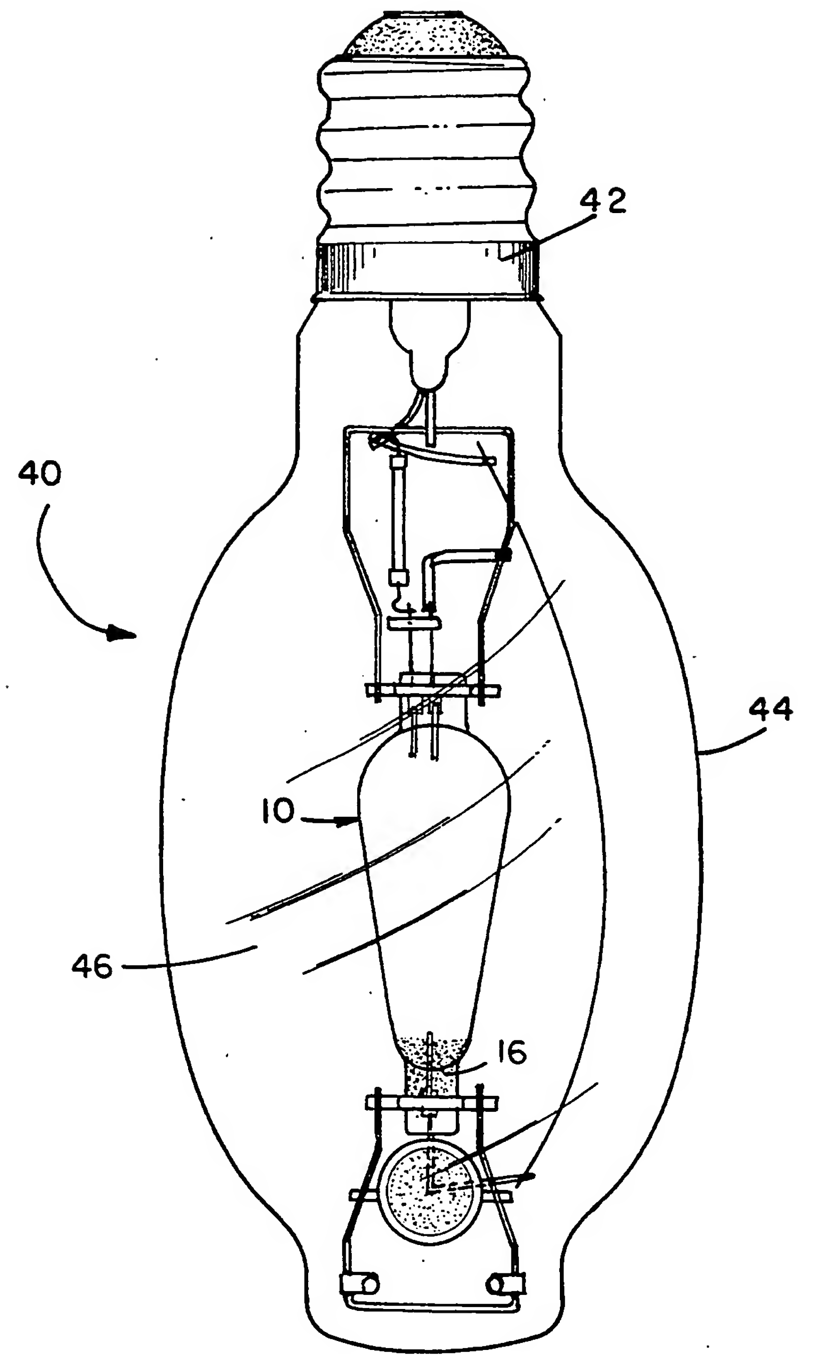
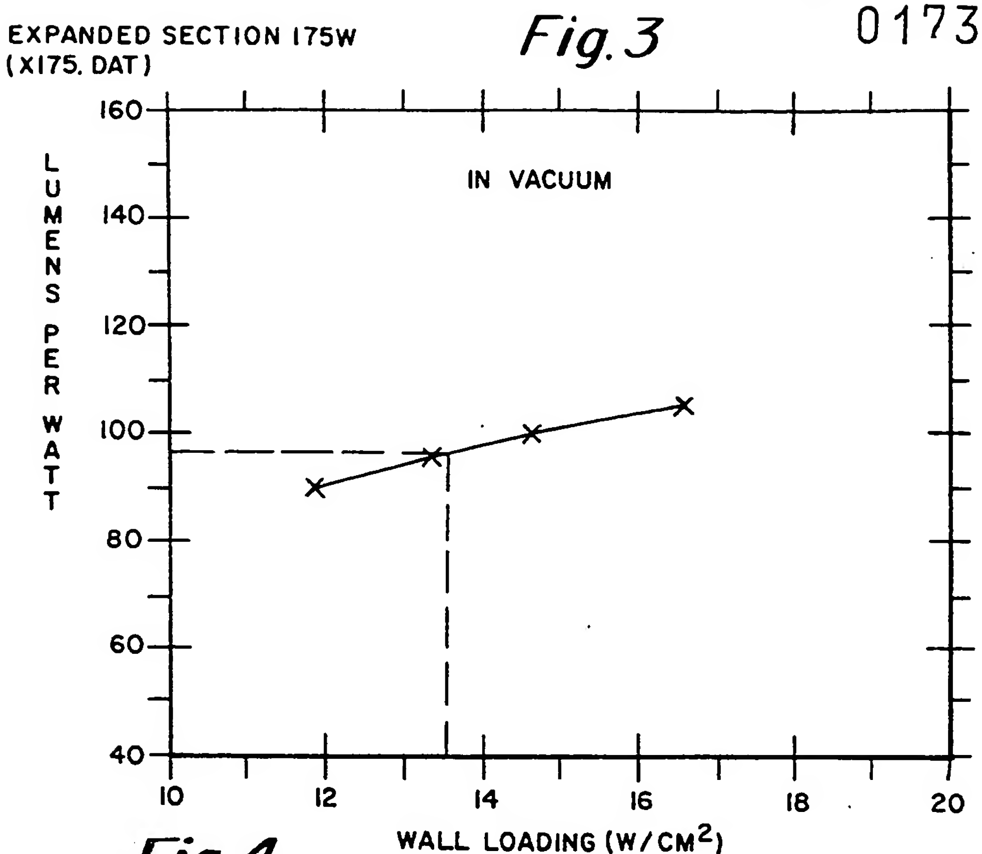


FIG.2

Fig. 3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18
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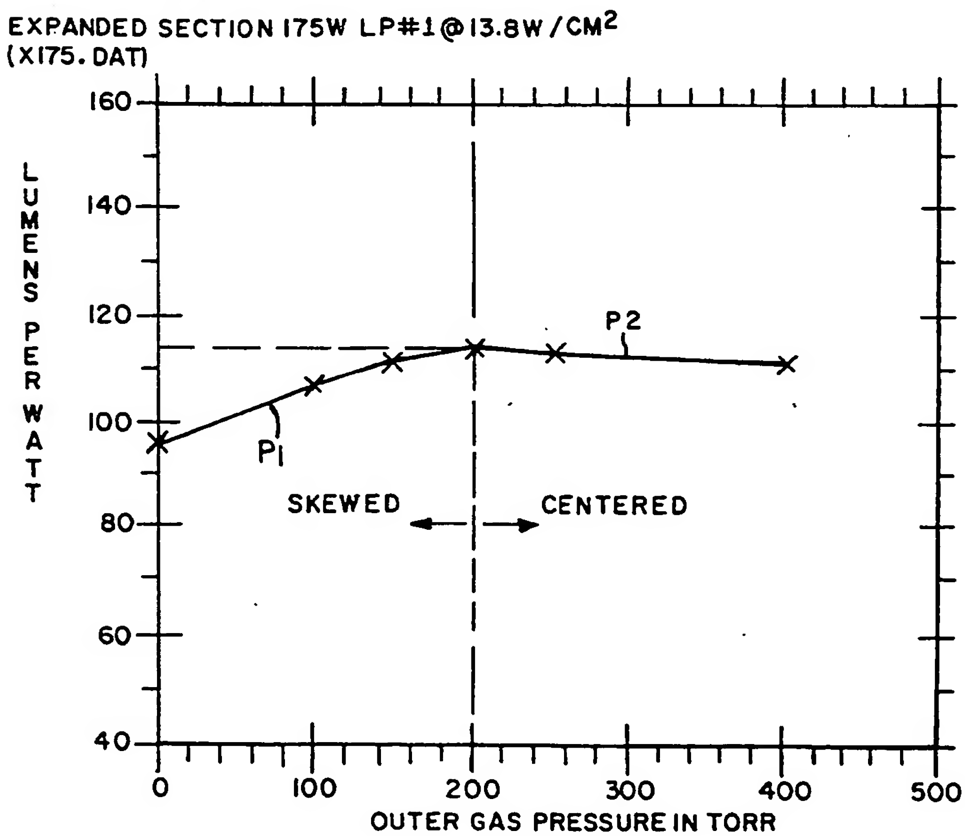
WALL LOADING (W/CM2)

Fig. 4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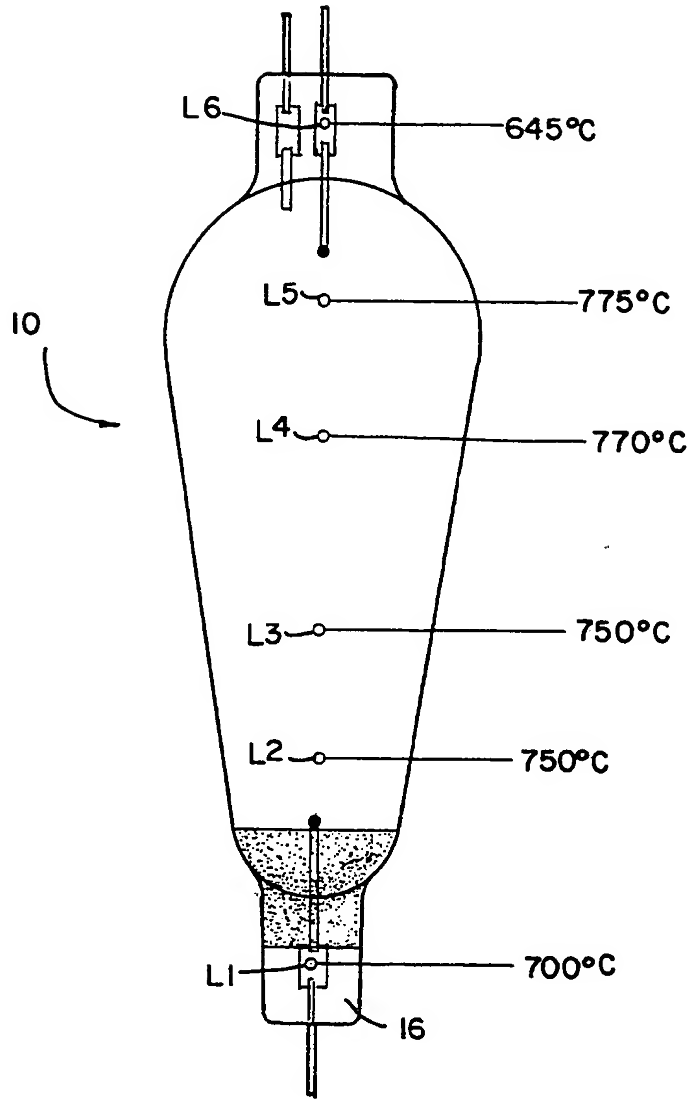

FIG.5

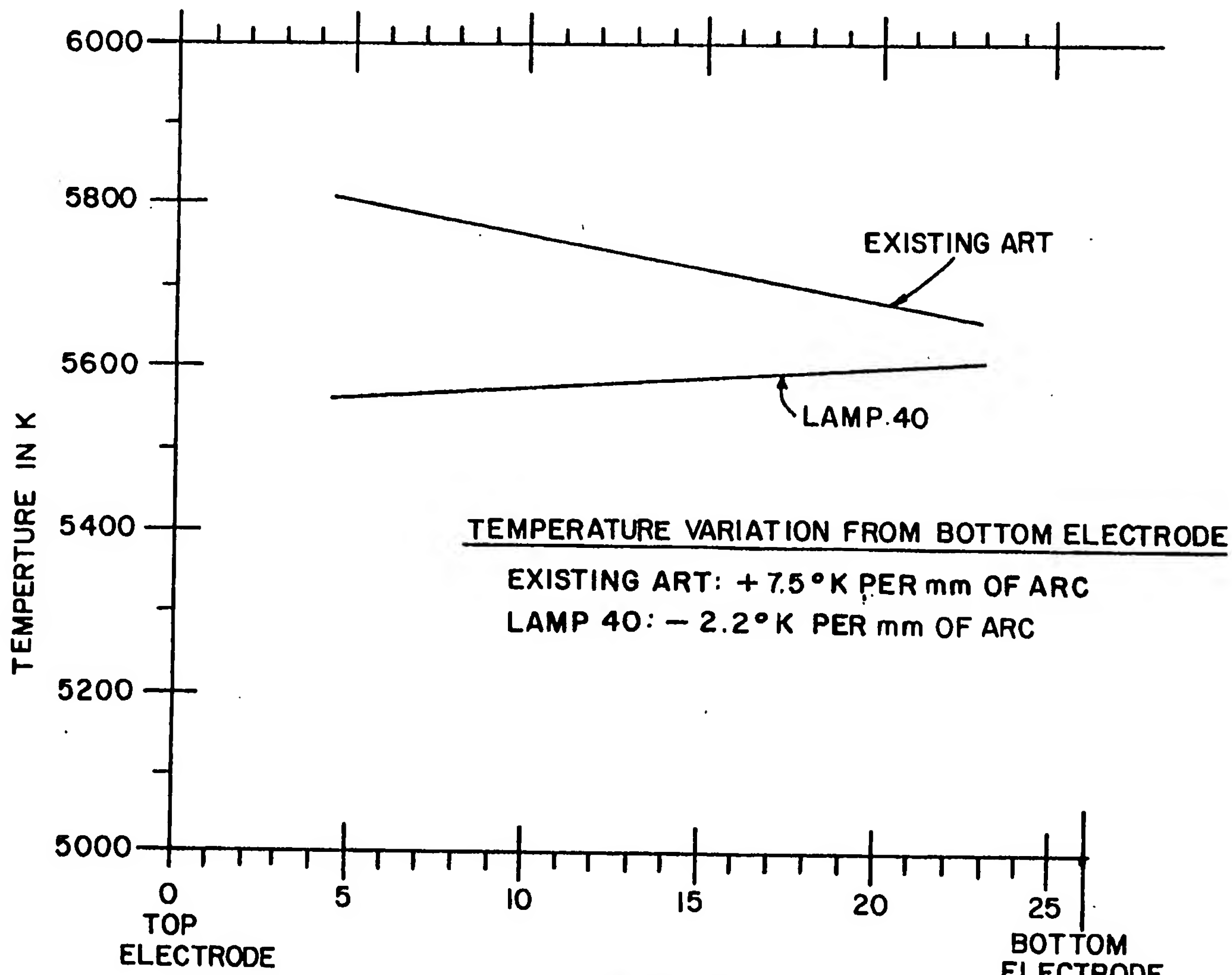
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FIG.6

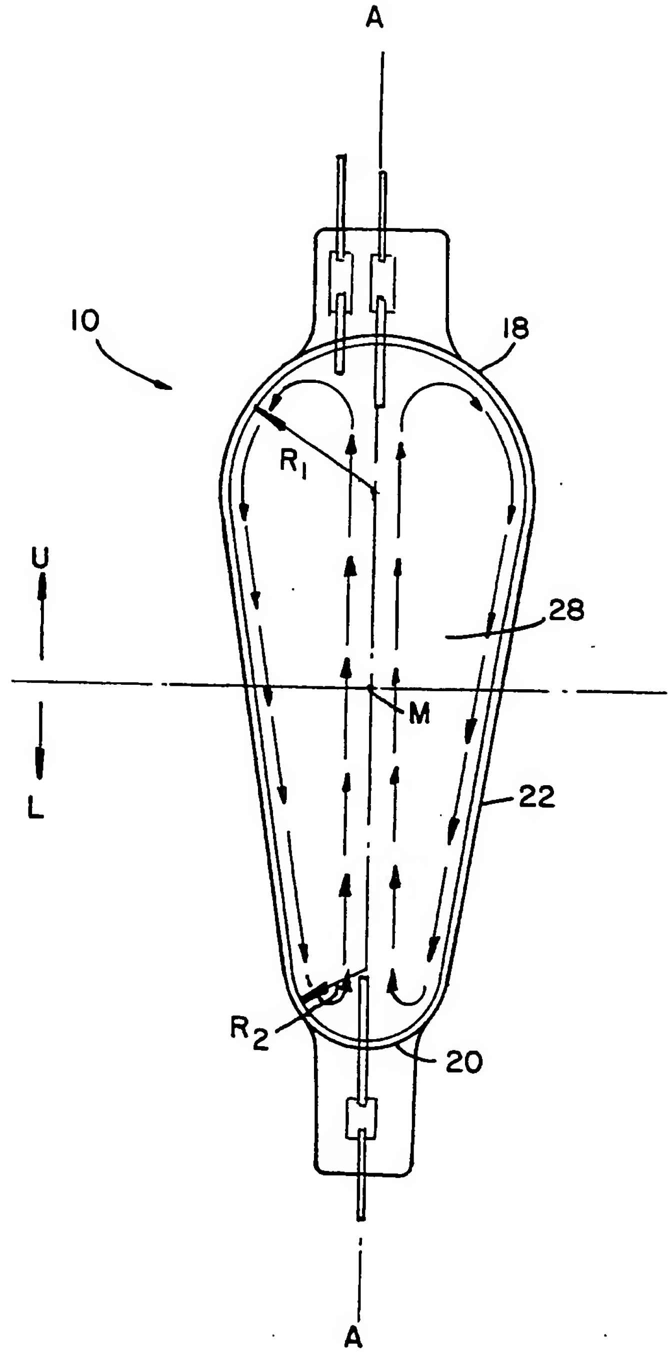

FIG.7

0173347

Application number

European Patent Office

EUROPEAN SEARCH REPORT

EP 85110969.4

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y A	EP - A1 0 034 056 (NGK INSULATORS) * Fig. 16; page 1, line 1 - page 2, line 5; page 24, line 27 - page 25, line 28; claims 1,3,5,9 * --	1-5 8	H 01 J 61/30 H 01 J 61/82
D,Y A	US - A - 3 883 766 (FOHL) * Column 2, line 48 - column 4, line 21; claims 1-3 * --	1-5, 8	
A	PATENT ABSTRACTS OF JAPAN, unexamined applications, E section, vol 7, no. 288, December 22, 1983 THE PATENT OFFICE JAPANESE GOVERNMENT page 97 E 218 * Kokai-no. 58-165 239 * & JP-A-58-165 239 --	1,4,8	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DE - A - 1 589 342 (SIEMENS) * Fig. 2; page 1, lines 15-26; page 4, lines 11-17 * ----	1,4	H 01 J 61/00 H 01 J 5/00 H 01 J 9/00 H 01 J 17/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	07-11-1985	BRUNNER

CATEGORY OF CITED DOCUMENTS

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